Simulation Data Management – enabler for credible Digital Twin
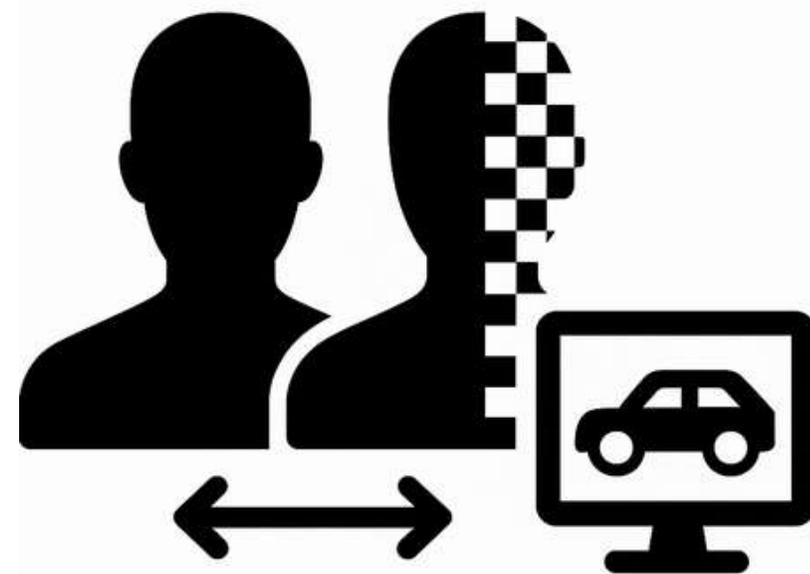
Dr. Alexander Mahl, PDTec AG
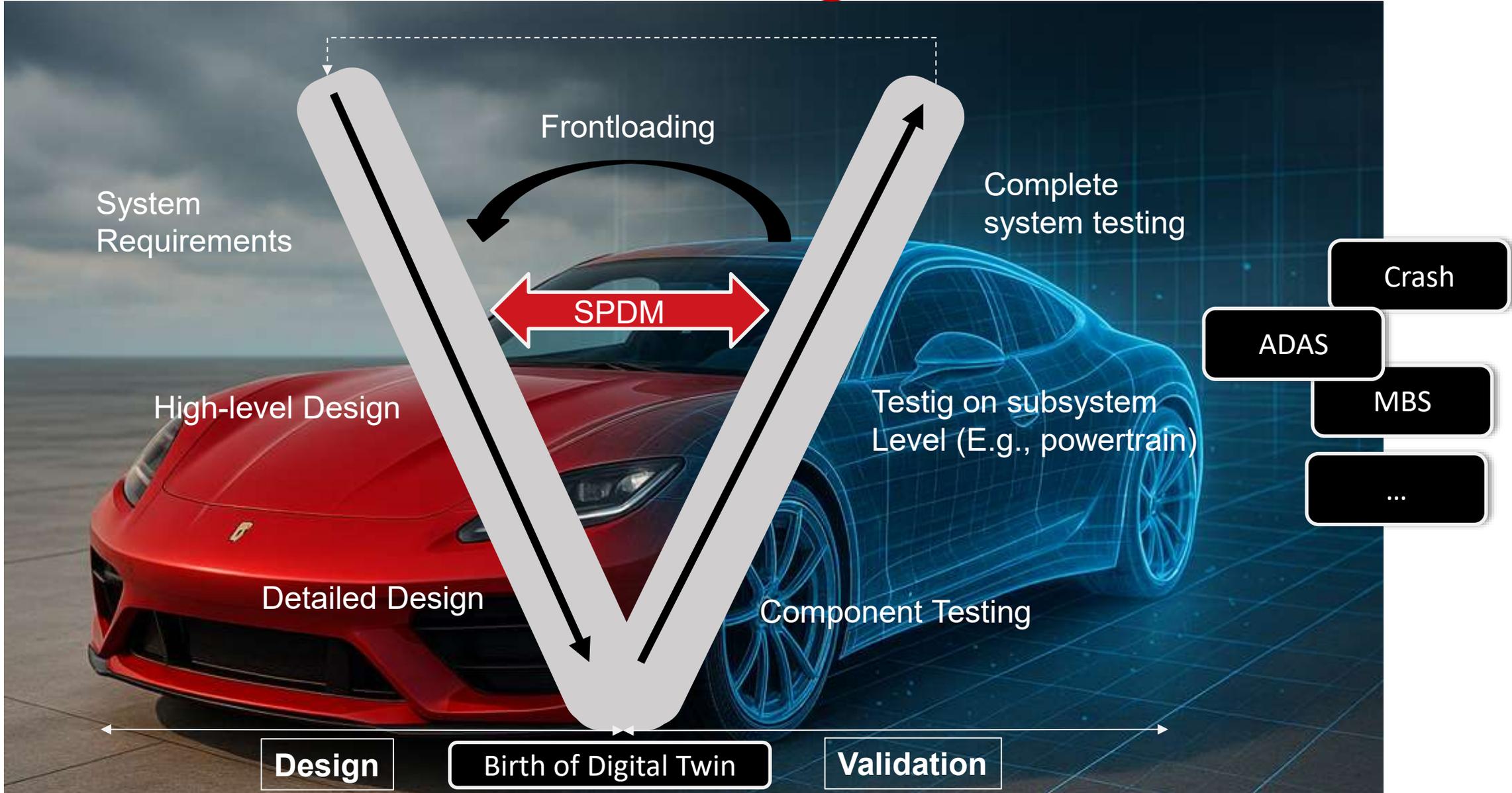
Digital Twin – Definition

- **Definition**
  - Digital twins are virtual representations of physical products, processes, or systems that enable real-time monitoring and simulation
  - They facilitate analysis, evaluation, and optimization throughout the entire product lifecycle

- **Benefit**
  - This enables developers to detect problems much earlier in design process ("fail early") and also to more efficient find "optimal" solution for design of the product

V-Model in Context of Digital Twin

Frontloading

System Requirements

Complete system testing

SPDM

High-level Design

Testig on subsystem Level (E.g., powertrain)

Crash

ADAS

MBS

...

Detailed Design

Component Testing

Source background image: ChatGPT

Design

Birth of Digital Twin

Validation

Coupling multiple disciplines in Digital Twin

- A digital twin involves the aggregation of data and information from diverse sources enabling a holistic and coherent view of the system's behaviour
  - E.g., involve systems and geometry simulations

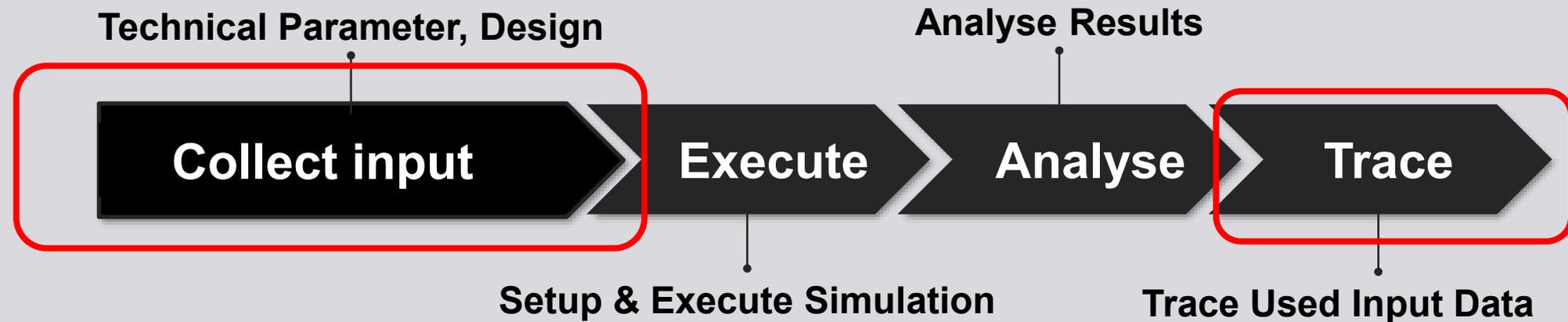**Design & Tech param.**

CFD

NVH

Crash

ADAS

MBSE

...
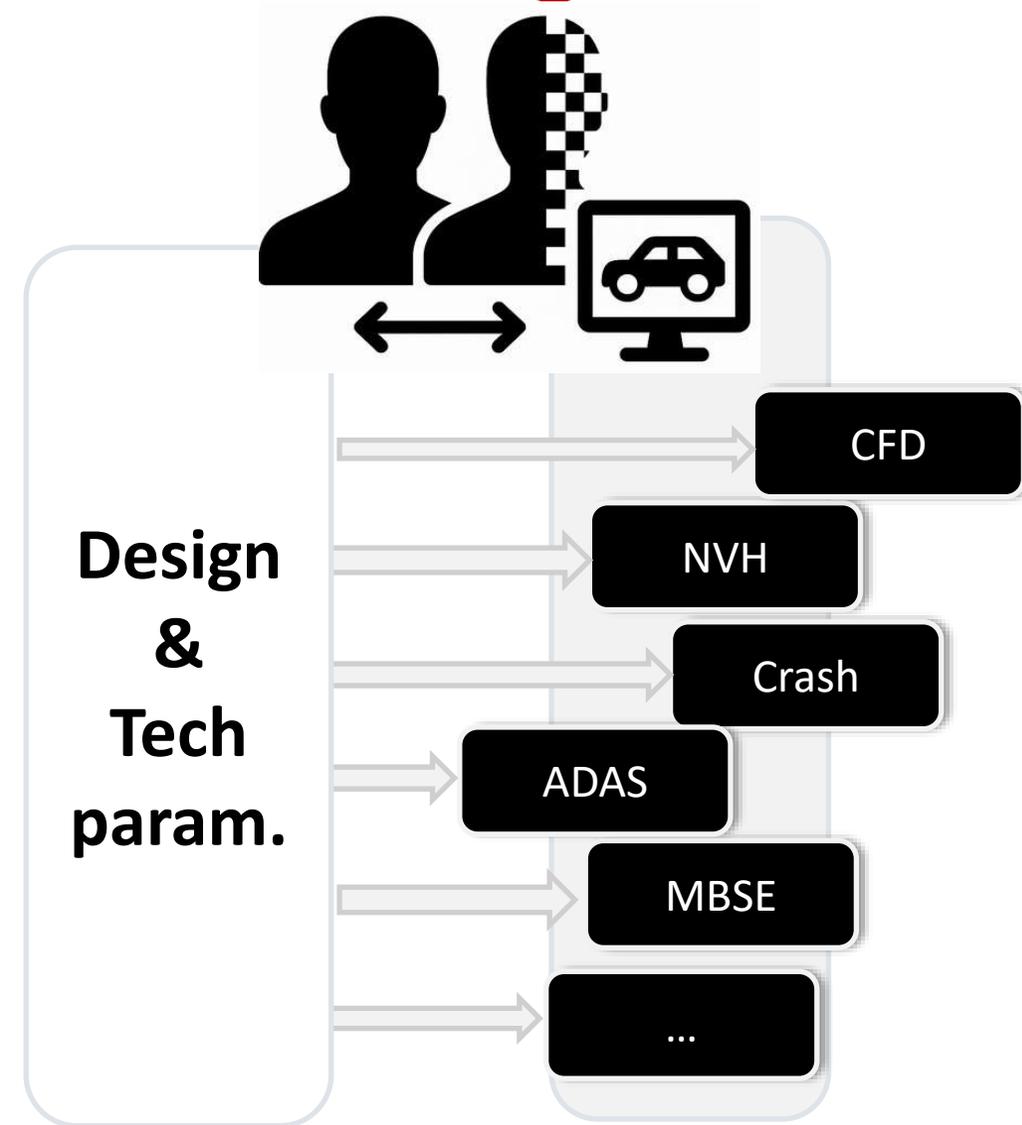
Motivation

How can setup of digital twin be done efficiently?

How to trust the digital twin (credibility) ?
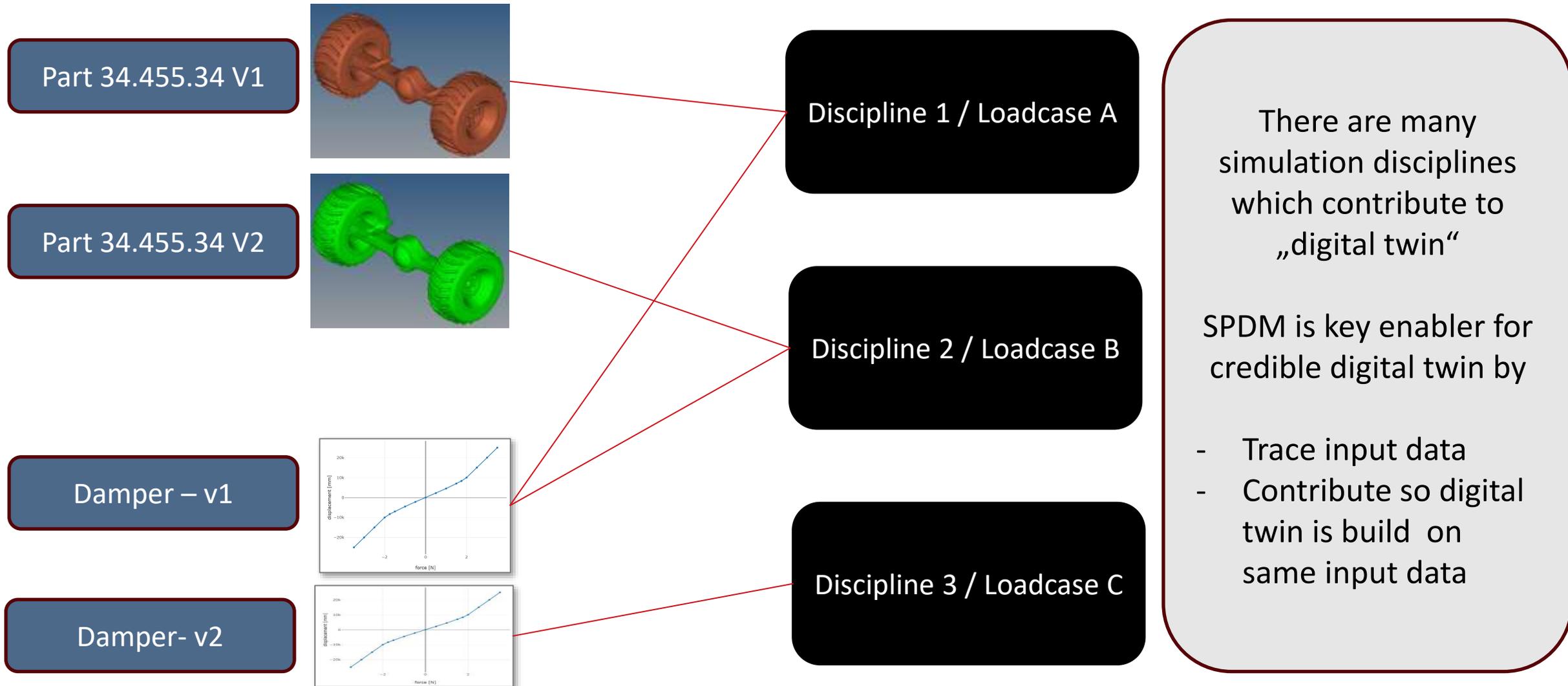
Management Perspective

Technical Perspective

Technical Parameter, Design

Analyse Results

Collect input → **Execute** → **Analyse** → **Trace**

Setup & Execute Simulation

Trace Used Input Data

Data flow in interdisciplinary setup
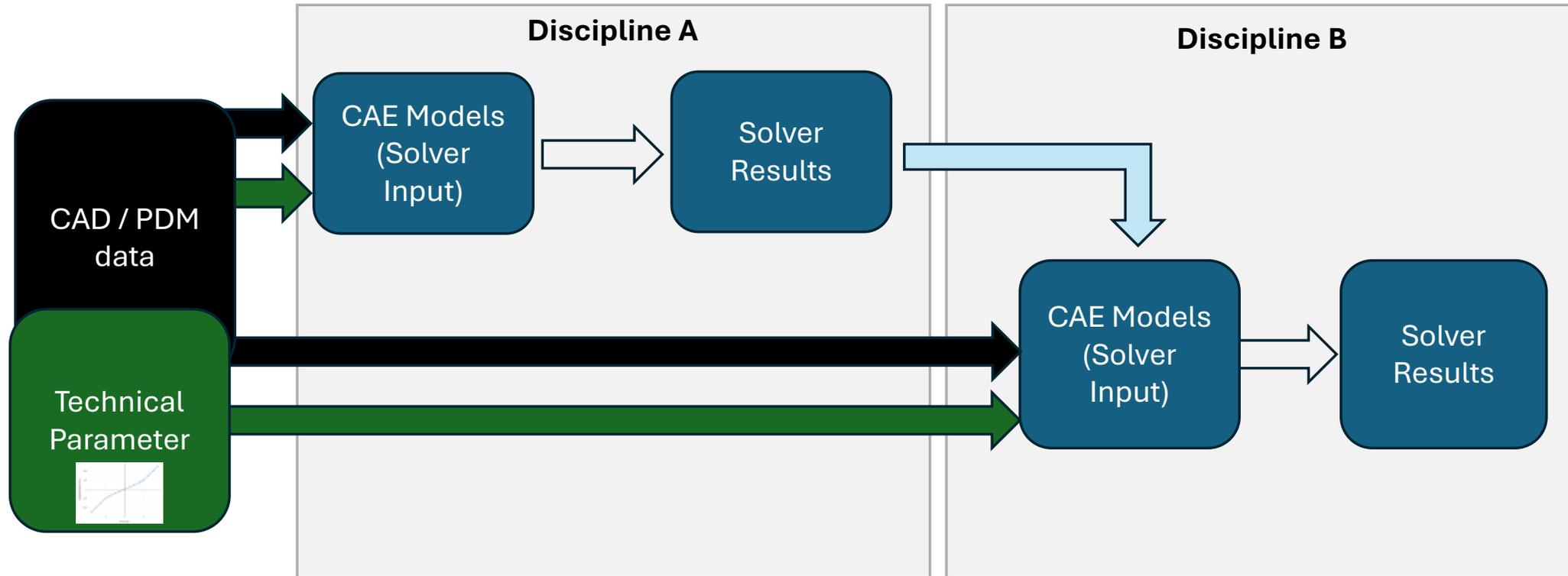
SPDM – Key enabler of credible Digital Twin

Part 34.455.34 V1

Part 34.455.34 V2

Damper – v1

Damper- v2

Discipline 1 / Loadcase A

Discipline 2 / Loadcase B

Discipline 3 / Loadcase C

There are many simulation disciplines which contribute to „digital twin"

SPDM is key enabler for credible digital twin by

- Trace input data
- Contribute so digital twin is build on same input data
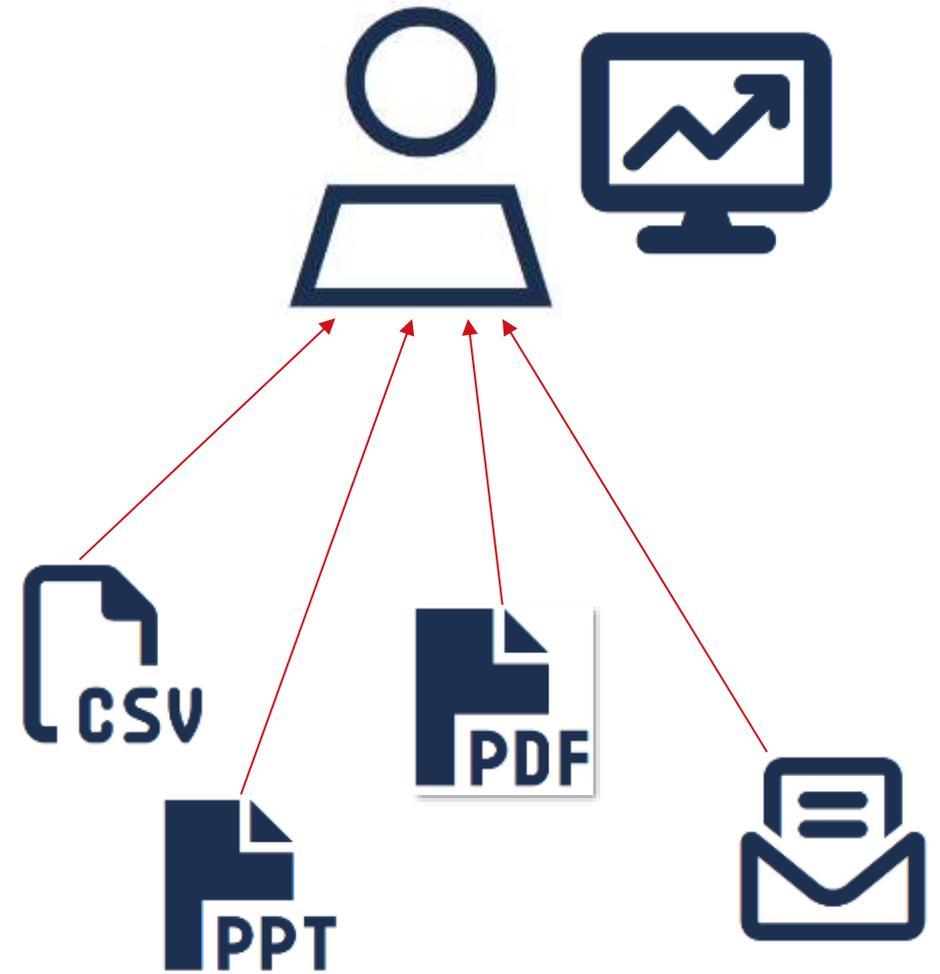
Technical Parameters – Definition

- Technical parameters or technology data describe the (non-geometric) properties of an entire product, component, or (sub-)system (e.g., brake system).

- Examples of technical parameters:
  - Mass
  - Centers of gravity
  - Bushing curves (e.g., of the front axle)
  - Engine maps
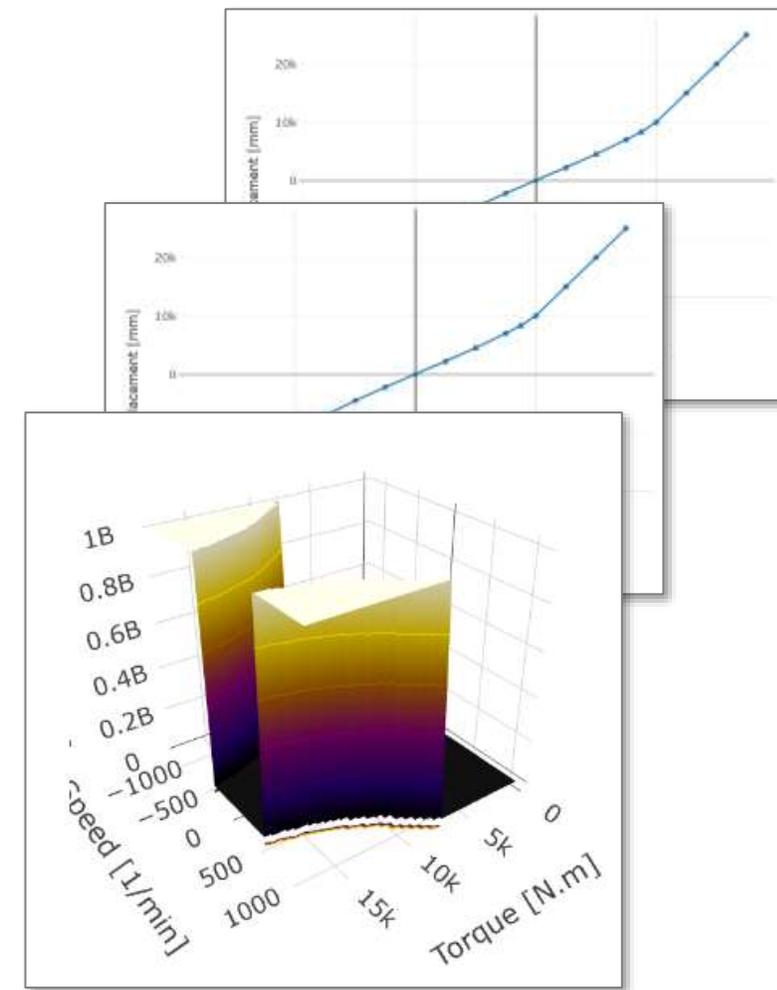
Technology Data – typical Problems

- Data is provided in various data formats
- Collection of data
  - Responsible for respective technology data not known
  - No "single source" Management of technology data available
  - Available PDM systems for geometry data are typically not ideal
- Supplier integration is not uniformly resolved

Technical Parameter as important input for credible Digital Twin

- For setup of credible digital twin with large / complex simulation models, a credible parameterization process is necessary

- Technical parameter used as bases for simulations needs to be
  - Of high quality
  - Complete
  - Single source for all discipline

- Traceability of technical parameters regarding usage within simulation models is extremely important

Remark:
There are several standardization activities in this area – for example ProSTEP iViP groups Functional Data Exchange (FDX) and "SmartSE"

Source: [1]

Bricks of the overall Concept

- Catalog mechanism for representing technical parameters in a management system ←

- Process configurator for the ordering and delivery workflow to provide data on a needs-driven basis

- Dashboard mechanism for the visual presentation of delivery progress

- Plugin mechanisms for the automatic population of solver models ←

- Mechanism for automated setup of simulation run models

- Plugin mechanism for CAE Tool Integration ←

- Tracking and visualization of the data flow in the CAE process ←

Catalogue Definition

Catalogue

Bushing_front_axle: TechDataSet

- Translational Stiffness X
- Translational Stiffness Y
- Translational Stiffness Z

Type: curve
X-axis=„" ...
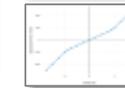
- Rotational Damping X
- Rotational Damping Y
- Rotational Damping Z

Type: singleValue
Unit: Euc

instance

P1_456.600.810.A_FrontAxleBushing

...

Px_123.600.810.A_FrontAxleBushing

- Project Px
- Derivate A
- Derivate B
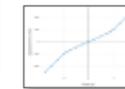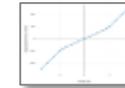- Milestone =M1
- System =FrontAxis

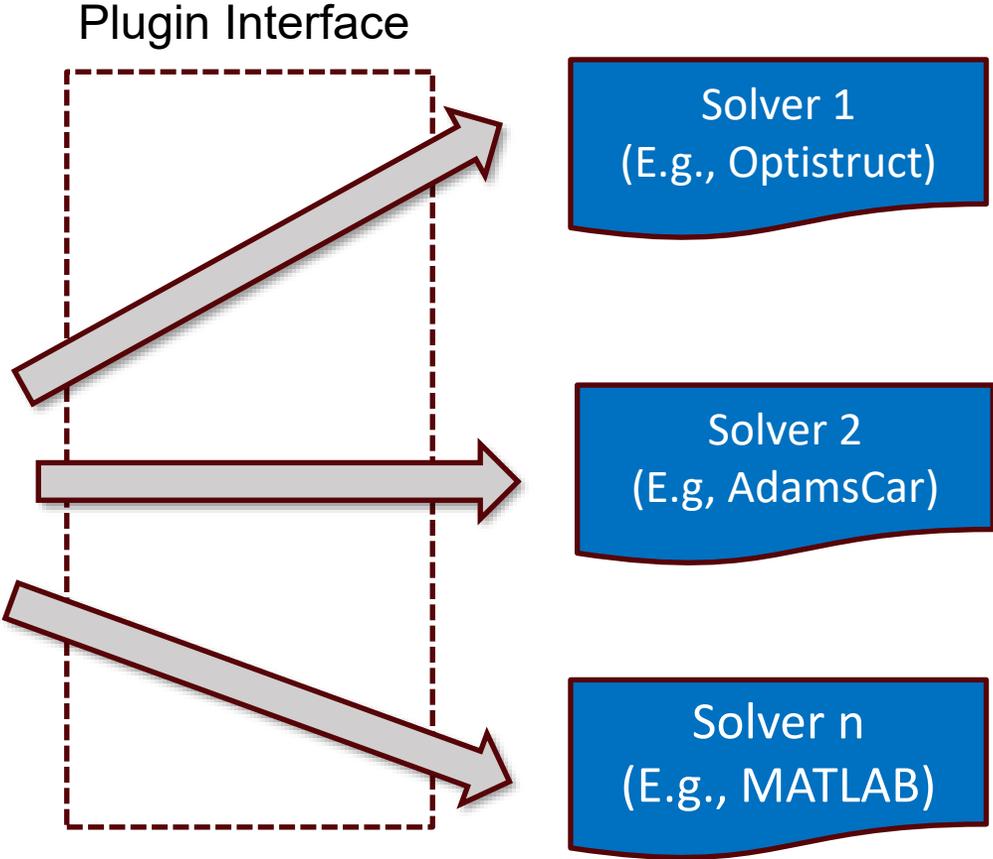| Translational Stiffness X | |
| Translational Stiffness Y | |
| Translational Stiffness Z | |

Rotational Damping X	250
Rotational Damping X	250
Rotational Damping X	60

Automatic setup of solver specific representations of Parameters

Plugin Interface

Solver 1
(E.g., Optistruct)

Solver 2
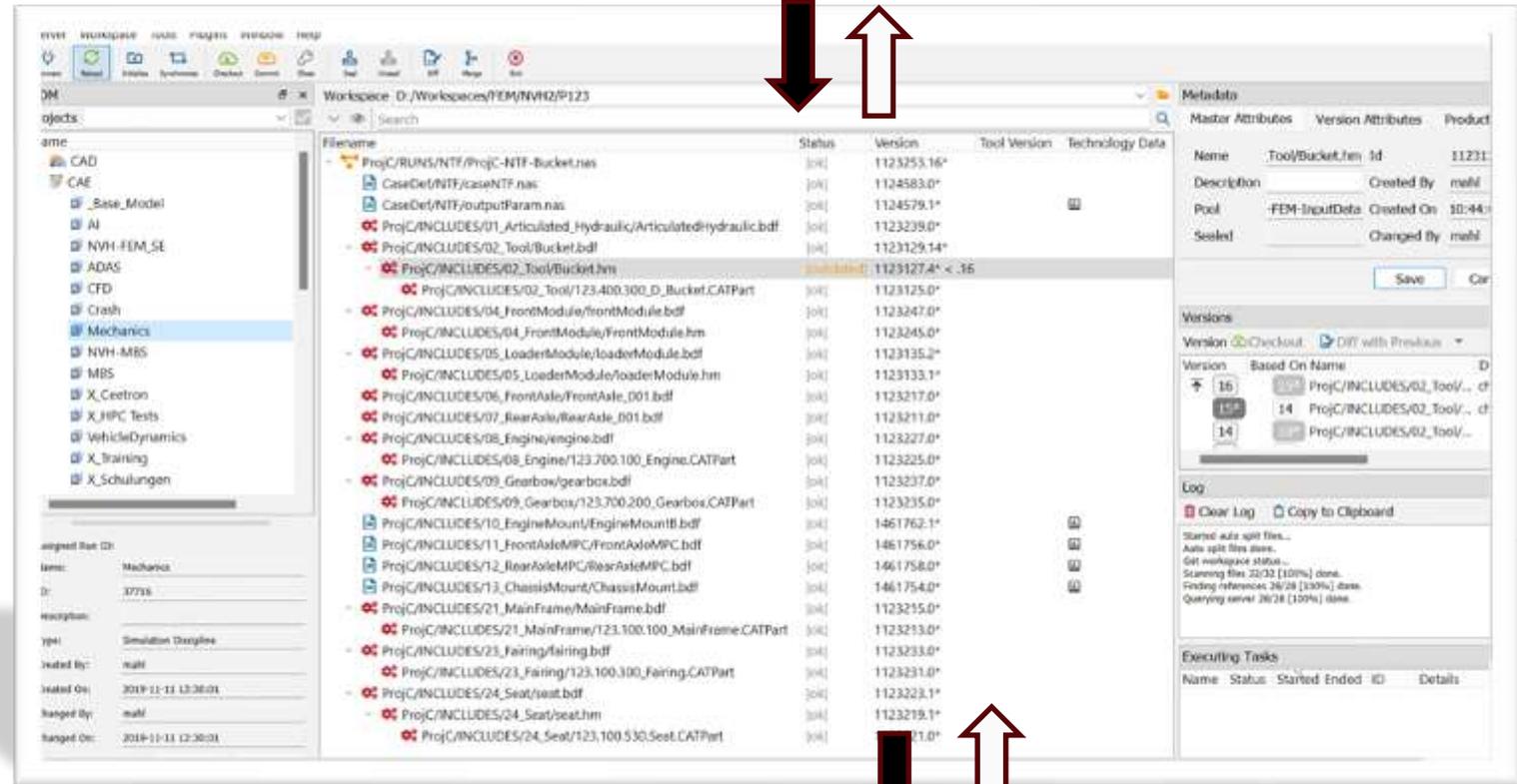(E.g, AdamsCar)

Solver n
(E.g., MATLAB)
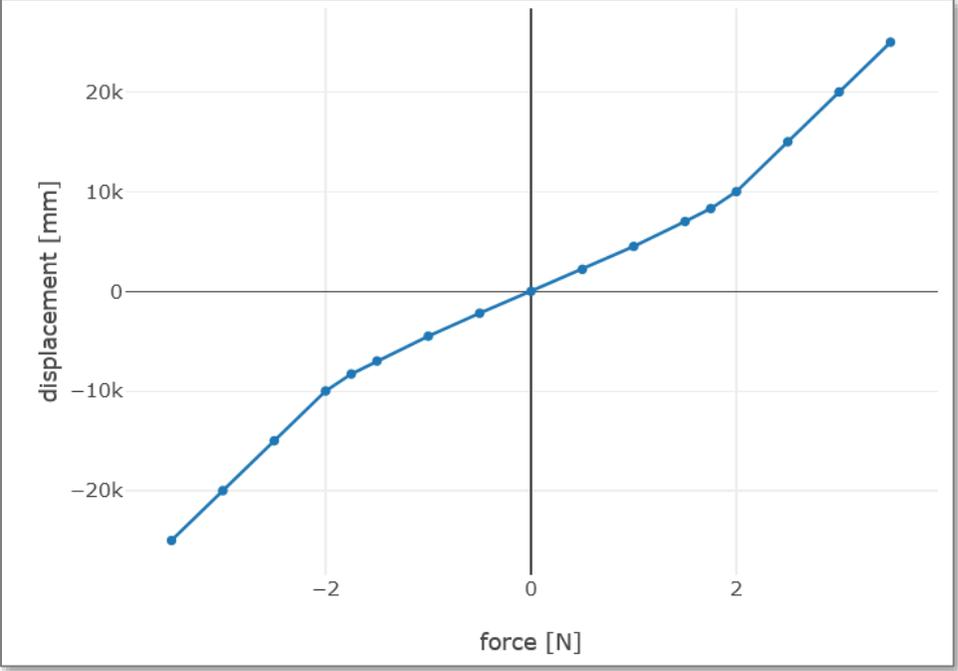
Efficient setup of CAE models
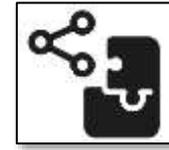
- Interaction with local CAE data (and CAE Tools)

- Generic mechanisms for Tool-Integration without customizing

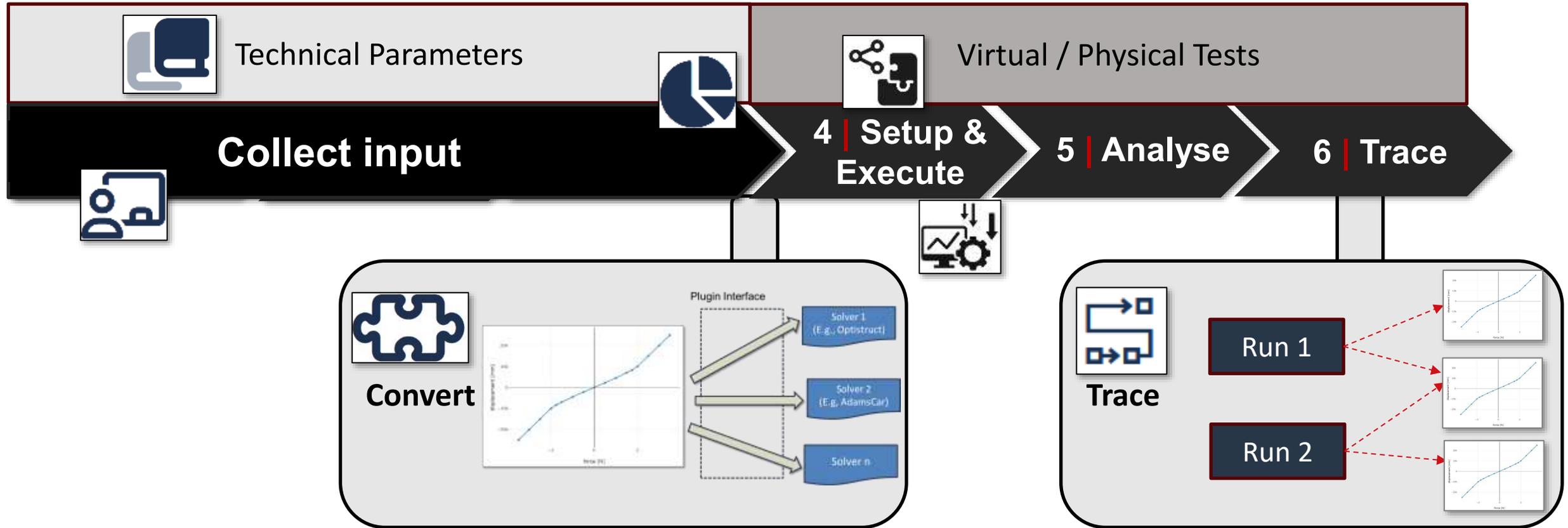- Plugin-interface for advanced support of processes / CAE Tools
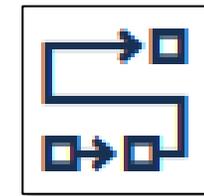

SimData Manager (Cloud)

Local files

Overall view on process to setup a creditable Digital Twin

Traceability

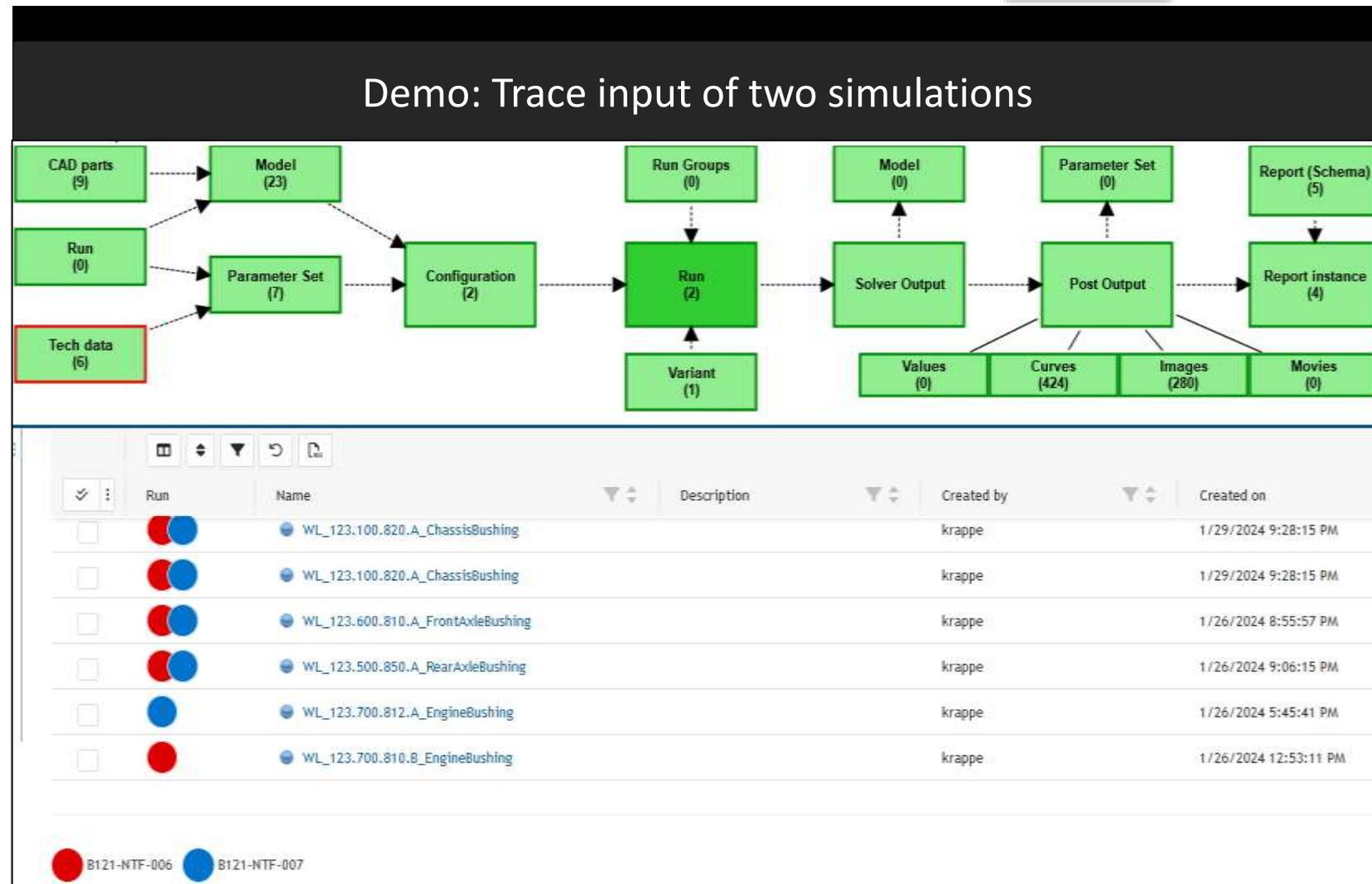- **Visualization of data usage**

  Trace Input data (technology data, CAD) for each simulation or report

- **Analyze differences in input**

  Recognize differences in input data from multiple simulations

- **Visualization of the history of items**

  Visualize the history of runs, models, or parameters

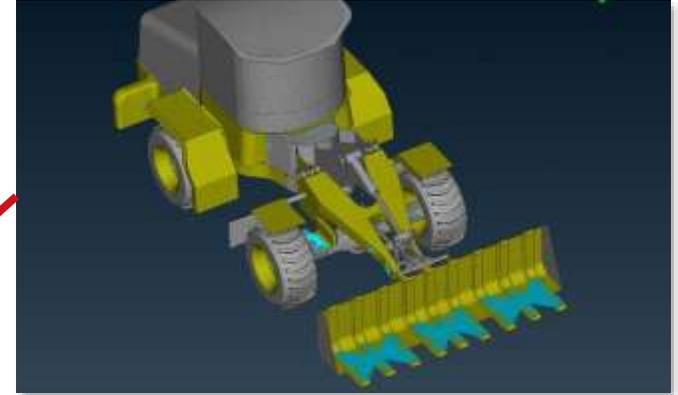
Demo: Trace input of two simulations

Traceability across simulation disciplines as enabler for credible Digital Twin
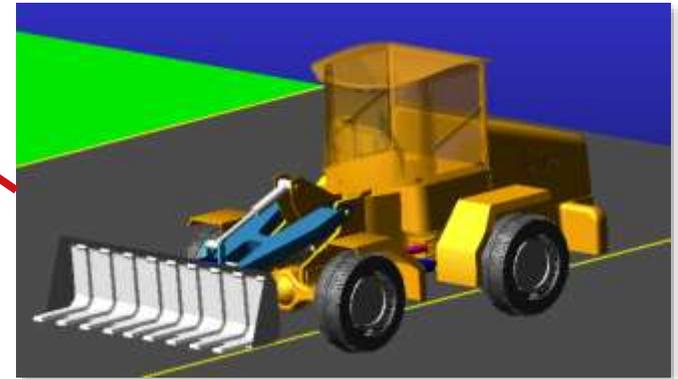
- Ensures that (release-relevant) simulations are based exactly on the same input data
  - Cross-disciplinary
  - Verifiable at any time and with the "push of a button"

FEM

MBS

Tech Data

PDM Data
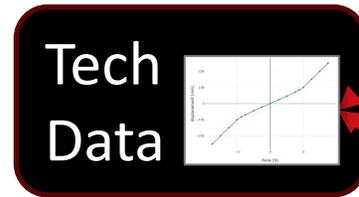
Crash, ADAS and many more...

Summary – SimData Manager

How can all simulation engineers work and collaborate efficiently?

How to trust simulation results?

SimData Manager — **Driving CAE with Data.**

» … enables teams to collaborate efficiently, with seamless process integration driving impactful virtual product development

» … ensures data continuity by enabling efficient and seamless management of simulation data

» … Ensures transparency with traceability of all input data in the respective engineering results

You have questions – **we** provide answers!

sales@pdtec.com

References

- [1] Functional data management as the basis for reliable simulations, Michael Baumann, VDI Knowledge Forum 2024 (Baden-Baden)